Thermal Expansion of Liquid Scintillator in NOvA Extrusions

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Calculation of the difference in volumetric expansion of liquid and PVC with temperature for one NOvA extrusion cell:

Volume of one Cell

$w := .030$ Width of cell in m

$thick := .040$ Thickness of cell in m

$Length := 17.5$ Length of cell in m

$Vo := w \cdot thick \cdot Length$

$Vo = 0.021$ Volume in cubic meters

Vt is the volume at temperature t.
Vo is the original volume at 0 degrees C
t is the temperature

$\alpha := .000682$

$\beta := .000001140$

The parameters α, β, γ were found on page 1696 of the Handbook of Chemistry and Physics-24th Ed. These are the values for olive oil since mineral oil is not shown.

$\gamma := -.0000000053$

$t1 := 20$ $t2 := 35$

$Vt1 := Vo \cdot \left(1 + \alpha \cdot t1 + \beta \cdot t1^2 + \gamma \cdot t1^3\right)$

$$\Delta oil := \frac{Vt2 - Vt1}{Vo}$$

$\Delta oil := \alpha \cdot (t2 - t1) + \beta \cdot \left(t2^2 - t1^2\right) + \gamma \cdot \left(t2^3 - t1^3\right)$

$\Delta oil = 0.011$

Volume Expansion of PVC

$\varepsilon := .00007$ Coefficient of Thermal Expansion of PVC per degree C

$\Delta T := t2 - t1$ Change in temp in degrees C = t2-t1

$\Delta T = 15$

$\Delta pvc := \left[\left[(\varepsilon \cdot \Delta T)^3\right] + 3 \cdot (\varepsilon \cdot \Delta T)^2 + (3 \cdot \varepsilon \cdot \Delta T)\right]$

$\Delta pvc = 3.153 \times 10^{-3}$

Difference in volumetric expansion between oil and PVC Cell

$Diff := Vo \cdot (\Delta oil - \Delta pvc)$

$Diff = 1.645 \times 10^{-4}$ Difference in volume expansion in cubic meters for one cell - multiply by 1000 to get the volume difference in liters

Conclusion: The oil in a single 3 cm x 4 cm x 17.5 m cell expands (or contracts) by 0.1645 liters per 15 deg C, relative to the volume of the PVC extrusion. Thus, the differential expansion for a single 32-cell extrusion is 0.35 liters per deg C.